Quick Look Response to Mr. Resnick's and Mr. Bauman's Request

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March 12, 2004

Acknowledgments

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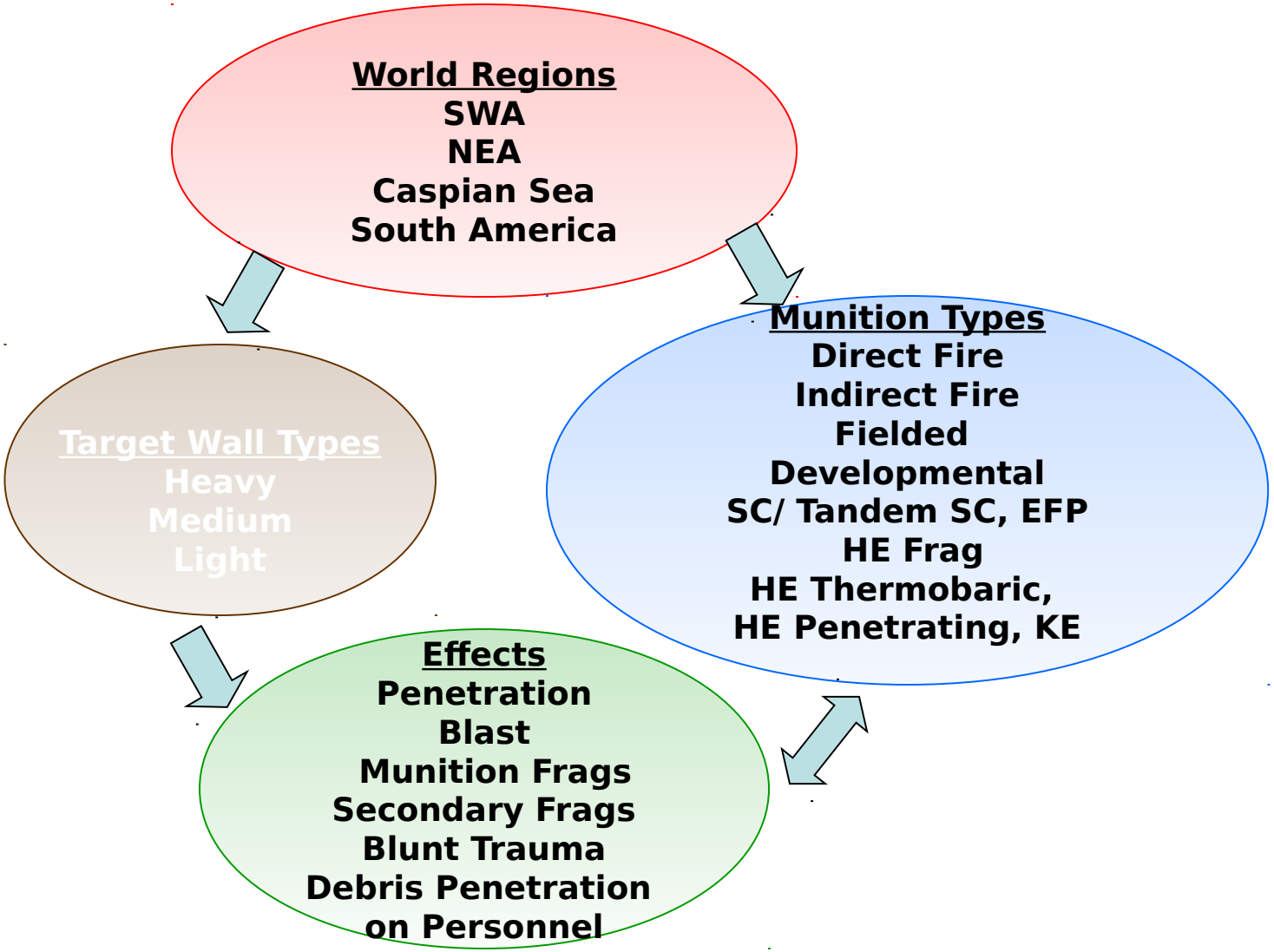
Matrix Implies Complex Weapons Effects in A MOUT environment. Not an easy question to answer.



We originally envisioned a two-year effort to determine what needs to be don
(SMTTB) – request proved difficult to answer in short time frame

Process Taken to Answer Request

- Reviewed Ellefsen body of work to determine wall types
- Contacted TRAC to determine currently (or near future) used scenarios
- Reviewed emerging requirements documents for developmental muni
- Reviewed JMEM for information on already fielded weapons
- Contacted SMEs for cost estimates in areas of blast, munition penetra

blunt trauma, and personnel incapacitation due to fragments

Differentiated wall types based on estimated penetration resistance:

- Very-heavy
- Heavy
- Medium
- Light

- Researched regions in each Scenario for wall types and cross-walked it with Ellefsen's body of work & ERDC World Construction Practices Database information

- Determined possible weapons effects against generic wall types

Target Wall Types*

Heavy	Medium	Light
Double RC wall 8 inches thick+	Single RC wall 4 inches thick	Wood Skin Exterior and Interior
Triple Brick Wall++	Double Brick (infill)	Wood Skin with Light Brick exterior
Rubble Stone Wall	Concrete Block wall (unreinforced, infill)	Steel Framed Walls (light cladding)
Concrete Block Wall Reinforced (mass)	cm brick + insulation+10 cm terra cotta tile Ellefsen 2004 Slide 20	Single Brick (infill)
	Brick/Block wall	Terra Cotta Block Infill Wall
	**Adobe Brick Wall	** Adobe Brick Wall

*We do not have penetration and lethality data for most of these walls. Estimates are based on engineering judgment.
**Light to Medium
+Medium to Heavy. R/C walls greater than 8 inches thick can be classified as
“Very Heavy”
++Possibilities exist in older areas of older cities of encountering 4 or 5 brick thick

World Regions and Target Wall Types

Concrete frame, terra cotta infill (Light)	cast-in-place concrete, 15-20 cm (Medium - Heavy	Mass const. CMU w/ rebar, grout every other cell (Medium)	load bearing masonry 54 cm thick (Heavy)
concrete frame, concrete block infill (Light)	R/C frame, Brick infill (Light-Medium)	R/C frame, brick infill (Light - Medium)	interior walls 12-38 cm (Light - Medium)
steel frame, composite (1 cm) (Light) up to 2 cm if sheet granite	Triple Brick to 4-brick (Heavy)	R/C frame, concrete block infill (Light-Medium)	R/C Frame, brick infill (Light-Med)
Steel frame, concrete block (20 cm thick) (Light-Medium)	R/C framed/ concrete block infill (Light)	R/C frame, terra cotta infill (Light)	R/C frame, concrete block infill (Light)
Load bearing stone (8-16 in [20 - 41 cm] thick) (Heavy)	Mass const. Concrete block w/ reinforcement and grout	Cast-in-place concrete (Medium-Heavy)	cast-in-place concrete, 15-20 cm (Medium-Heavy)
Concrete frame, brick infill (Light if single brick, Medium if Double Brick)	R/C, light cladding (Light)	Wood frame, wood sheathing (Light)	
Adobe, brick: Exterior 4 wythe - 21 inches(53 cm), interior 1-3 wythe, 6-14 (15 - 36 cm)inches thick (adobe made of mud and straw, sun dried) (Light-Medium)		Ungrouted CMU bearing walls 8 and 12 inch (20 and 30 cm) widths/CMU, interior is 2 wythe CMU or HCT (Light - Medium)	
		Hollow Core Tiles - less expensive than CMU and used more frequently (Light)	

Possible Weapons Effects Against Generic Wall Types (1 of 4) – Direct Fire

Direct Fire	Warhead Type	Fuze	**Heavy Wall**	**Medium Wall**	**Light Wall**	**Earth & Timber Field Fortifications**	**Heavy, Buried Reinforced Concrete Bunkers**
LOSAT	KE missile	None	KEP, SF	KEP, SF, ID(RM), CF, SC	KEP, SF, ID(RM)	KEP, SF, ID(RM),SC	NSE
CKEM	KE missile	None	KEP, SF	KEP, SF, ID(RM), CF, SC	KEP, SF, ID(RM), CF	KEP, SF, ID(RM), CF, SC	NSE
Javelin	Tandem Shaped Charge	Contact	SCP	SCP, BD,SD,SF	SCP, BD,SD,SF,SC,BT	SCP	NSE
Tow Bunker Buster	Penetrator HE/Frag	Delay	SD,BD,SF	SD,BD,SF,ID, CF,SC	SD,BD,SF,ID, CF,SC	BD, SF, ID, CF, SC, BT	NSE
TOW 2A (BGM-71E) (Anti-Tank)	Tandem Shaped Charge	Contact	SCP	SCP, BD,SD,SF	SCP, BD,SD,SF,SC,BT	SCP, BD,SF,BT	NSE
Dragon (M47)	Shaped Charge	integral contact fuze	SCP	SCP,BD,SD,SF	SCP,BD,SD,SF,SC, BT	SCP,BD,BT,	NSE

Weapons Effects of interest

NSE - No Significant Effect	CF - Case Fragments
KEP-Kinetic Energy Penetration	BT - Blunt Trauma
SF - Secondary Frag from wall	RM - Rocket Motor
ID - Internal detonation	SCP - Shaped Charge Penetration
BD - Breaching Detonation	EFPP - Explosively Formed Penetrator Penetration
SD- Structural Damage	SC - Structural Collapse

Possible Weapons Effects Against Generic Wall Types (2 of 4) – Direct Fire

Direct Fire	Warhead Type	Fuze	**Heavy Wall**	**Medium Wall**	**Light Wall**	**Earth & Timber Field Fortifications**	**Heavy, Buried Reinforced Concrete Bunkers**
AT-4 (Anti-Tank)	Shaped Charge	Contact	NSE	SCP,SD,SF	SCP,SD,BD,SF,BT	SCP	NSE
AT-8	Shaped Charge	Delayed	SD,BD,SF	SD,BD,SF,ID, CF,SC, BT	SD,BD,SF,ID, CF,SC, BT	SD,BD,SF,ID, CF,SC, BT	NSE
Joint Common Missile (JCM)	Tandem Shaped Charge	Precurser - Contact Main-Delayed	SD,BD,SF	KEP, SD, BD, SF, ID, CF, SC, BT	KEP, SD, BD, SF, ID, CF, SC, BT	KEP, SD, BD, SF,ID, CF, SC, BT	NSE
120 mm							
M830A1	Shaped Charge	Multi-purpose Prox	SD,BD,SF	SD,BD,SF	SD,BD,SF,SC, BT	SD,BD,SF, BT	NSE
M908 HEAT	Shaped Charge	Contact	SCP,BD,SD	SCP,BD,SD	SD,BD,SF,SC, BT	SCP,BD	NSE
105mm							
M393E3	HEP	Delay	SD, BD,SF	SD, BD,SF	ID, CF,SC, BT	SD, BD,ID, CF,SC,BT	NSE
M456 HEAT	Shaped Charge	Contact	SCP, SD, BD,SF	SCP, SD, BD,SF	SCP, SD, BD,SF	SCP,SD,SF	NSE

Weapons Effects of interest

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SD- Structural Damage	SC - Structural Collapse

Possible Weapons Effects Against Generic Wall Types (3 of 4) – Indirect Fire

Indirect Fire	Warhead Type	Fuze	**Heavy Wall**	**Medium Wall**	**Light Wall**	**Earth & Timber Field Fortifications**	**Heavy, Buried Reinforced Concrete Bunkers**
ATACMS-P	Penetrating /HE/Frag	Delay	KEP, SD, BD,SF, ID, CF ,SC, BT	KEP, SD, BD,SF, ID, CF, SC, BT	KEP, SD, BD,SF, ID, CF, SC,BT	KEP, SD, BD,SF, ID, CF, SC,BT	KEP, SD, BD, SF, ID, CF
GMLRS unitary	Penetrating /HE/Frag	Delay	KEP, SD, BD,SF,SC,BT	KEP, SD, BD, SF, ID, CF, SC, BT	KEP, ID, CF, SC, BT	KEP, SD, BD, SF, ID, CF, SC, BT	KEP, SD, BD, SF
155mm Howitzer							
Excalibur	Penetrating /HE/Frag	Delay	KEP, SD, BD,SF, ID, CF ,SC, BT	KEP, SD, BD,SF, ID, CF, SC, BT	KEP, SD, BD,SF, ID, CF, SC,BT	KEP, SD, BD,SF, ID, CF, SC,BT	KEP, SD, BD, SF
M549A1	HE/Frag RAP	Contact	SD, BD,SF	SD, BD,SF,SC, BT	SD, BD,SF,SC, BT	SD, BD,SF,SC, BT	NSF
M795	HE/Frag	Delay	KEP, SD, BD,SF, ID, CF ,SC, BT	KEP, SD, BD,SF, ID, CF, SC, BT	KEP, SD, BD,SF, ID, CF, SC,BT	KEP, SD, BD,SF, ID, CF, SC,BT	KEP, SD, BD, SF
M107	HE/Frag	Delay	KEP, SD, BD,SF, ID, CF ,SC, BT	KEP, SD, BD,SF, ID, CF, SC, BT	KEP, SD, BD,SF, ID, CF, SC,BT	KEP, SD, BD,SF, ID, CF, SC,BT	KEP, SD, BD, SF
105 mm							
M760	HE/Frag	Delay	SD, BD,SF	SD, BD,SF	ID, CF,SC, BT	KEP, BD,ID, CF,SC,BT	NSE
M548	HE/Frag RAP	Delay	SD, BD,SF	SD, BD,SF	ID, CF,SC, BT	KEP, BD,ID, CF,SC,BT	NSE

Weapons Effects of interest

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KEP-Kinetic Energy Penetration	BT - Blunt Trauma
SF - Secondary Frag from wall	RM - Rocket Motor
ID - Internal detonation	SCP - Shaped Charge Penetration
BD - Breaching Detonation	EFPP - Explosively Formed Penetrator Penetration
SD- Structural Damage	SC - Structural Collapse

Possible Weapons Effects Against Generic Wall Types (4 of 4) – Indirect Fire

Indirect Fire	Warhead Type	Fuze	**Heavy Wall**	**Medium Wall**	**Light Wall**	**Earth & Timber Field Fortifications**	**Heavy, Buried Reinforced Concrete Bunkers**
120 mm Mortor							
Precison Guided Mortar Munition (PGMM)	Penetrating /HE/Frag	Delay	SD, BD,SF	KEP, SD, BD, SF, ID, CF, SC, BT	KEP, ID, CF, SC, BT	KEP,ID, CF, SC, BT	NSE
M329A2	HE/Frag	impact, delay, or prox fuze	SD, BD,SF	SD, BD,SF	KEP, SD, BD, SF, ID, CF, SC, BT	SF,SC	NSE
81 mm							
M43A1	HE/Frag	Contact	NSE	SD, BD,SF	SD, BD,SF,SC,BT	NSE	NSE
M374 A3	HE/Frag	Contact	NSE	SD, BD,SF	SD, BD,SF,SC,BT	NSE	NSE
M821	HE/Frag	Delay	NSE	SD, BD,SF	SD, BD,SF, ID, CF, SC,BT	KEP, BD, SF, BT	NSE

Weapons Effects of interest

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For “Army class” weapons…

- Light walls are most common worldwide.
- Most weapons should work against light walls if fuzed for penetration.
- Most weapons will not work against very heavy walls.
- Focus should be on medium/heavy walls for delay fuzed weapons.

- If light walls are perforated with a delay fuze, not much ancillary debris is expected.
- If the munition is point detonating fuzed against a light wall, the fuze may not function - the functioning of the round will depend on the fuzing, and obliquity angle, i.e., a given wall will “appear” thicker to the round if the round impacts the wall at a 45^{o} angle, versus a 90^{o} angle.

- Very limited data exists.

- Tightly controlled experiments: 3-5 shots per effect, per munition, per wall

Quick Look Expected Potential Costs

1.) **Blast: "Simple Test"** = $100k

The 'simple test' implies portable recording instrumentation (two 16 channel units), transducers and set up to measure:

a. T-zero for each recorder (2 channels)
b. 3 blast test devices (12 channels) to evaluate 'blast/lung' injury level
c. 6 'quasi-static pressure' measurements to evaluate structural load (6 channels)
d. 3 'peak pressure' measurements to evaluate structural loading and warhead effects (3 channels)
e. 6 'event markers' (piezo pins or breakwires to provide time marker for breaking doors, structural failures, etc) (6 channels)

2.) **Blunt Trauma/Acceleration on personnel requires using Hybrid III ATD type data collection** = cost up to $300k/ATD + $80k/blast shield for instrumentation van that collects Hybrid III ATD data.

3.) **Fragmentation on Personnel:** PIMMS data collection ARL WMRD $10k/week, AMRDEC requires $5k/shot if they are just given data to do PIMMS analysis. 1-2 week data reduction….approximate $30k/shot.

4.) **Experimentation:** If warheads exist, a tightly controlled static shot (experimentation) would be about $5k per shot. For gun-launched warheads, this cost would be a little more expensive.

5.) **Flight Test**: Biggest cost is "set-up." Example: for a test on a firing range, an approximate cost would be $300k* + $90-100k for the assessment (3 shots 1 target). This does not include the test facility cost. It may take 2 or 3 shots to get the information you want.

6.) **Arena testing:** Three shots = $320k.

7.) **Penetration:** 10-15k ERDC gun, test art, sabot, high speed cameras (2500/week to rent) per shot
Cost (3/week simple shot). Accelerometers additional cost.

*"Range Time Costs" may change drastically due to test location.